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ACCESS TUBES AND TIMERS FOR USE WITH NUCLEAR SOIL MOISTURE METERS

The Central States Forest Experiment Station has been experimenting with commercially available nuclear devices for measuring soil density and moisture percent at and below the surface. This report gives some recommendations for their use resulting from our experiments.

KIND OF ACCESS TUBE INFLUENCES SUBSURFACE MOISTURE NUCLEAR PROBE READINGS

The casing of access holes for subsurface nuclear probes makes the taking of repeated reading in the same place and at the same depth practical. But when casing is used it is important to know the exact effect it will have on the reading obtained. We compared access tubes of plastic, aluminum, iron, steel, and brass for their influence on soil moisture measurement with nuclear equipment.

Readings from soil moisture nuclear equipment, expressed as i.p.m. (impulses per minute), are converted to Pv (soil moisture, percent by volume) by means of a calibration curve. The equation of such a calibration curve is of the form $M = a + (1/b)X$--where M is soil moisture content in Pv, a is a constant, b is the slope of the calibration curve in impulse rate per moisture percent, and X is the impulse rate reading.[1] The higher the b value (the steeper the slope of the calibration curve) the easier it is to detect small soil moisture differences with the nuclear probes. And, other things being equal, the slope of this calibration curve is steeper in an uncased than a cased hole. Kind of tubing has a greater effect on the slope of the calibration curve of a subsurface density probe than on that of a moisture probe because gamma rays from a density probe have less penetrating power than neutrons from a moisture probe. With denser access tubes fewer gamma rays get through the tube to react with the soil.

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[1] Douglass, James E. A method for determining the slope of neutron moisture meter calibration curves. U.S. Forest Serv. Southeast. Forest Expt. Sta. Paper 154, 6 pp., illus. 1962.

We took readings with the subsurface moisture nuclear probe inside nine different kinds of tubing. Tubes were first suspended in air and then, with bottoms plugged, held vertically in a 4-foot-deep pool of water. The pool was wider than 18 inches, the diameter that is considered to provide an infinite volume for the type of nuclear probe under study.[2]

Table 1.--Subsurface moisture nuclear probe readings inside nine different kinds of access tubing

Tubing: Kind	Tubing: Outside diameter (inches)	Tubing: Wall thickness (inches)	Average reading: Air	Average reading: Water
			I.p.m.[1]	I.p.m.[1]
Aluminum, 6061-T6 alloy	1.625	0.035	42	24,652
Plastic, rigid cellulose, acetate, butyrate	1.750	.065	45	24,613
Brass, "half-hard"	1.625	.035	44	21,965
Steel				
Cold drawn, low carbon, seamless	1.625	.035	43	22,102
Cold rolled, low carbon, flash welded	1.625	.035	45	22,102
Electric metallic	1.740	.065	41	19,797
Electric metallic	2.197	.065	45	16,892
Iron				
Regular galvanized pipe	1.900	.145	45	15,374
Regular galvanized pipe	2.375	.154	44	13,083

[1] Impulses per minute.

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[2] McHenry, J. Roger. Theory and application of neutron scattering in the measurement of soil moisture. Soil Sci. 95: 294-307, illus. 1963.

Averages of 26 readings taken in each tube suspended in air fell within a small range. The low value was 41 i.p.m. for electric metallic tubing (1.74 inch outside diameter) and the high value was 45 i.p.m. for the plastic tubing (table 1). These low readings are of the magnitude that might be expected from background radiation. Differences between tubes were not statistically significant even at the 5 percent level of probability.

Averages of the 18 readings taken in each tube with the probe held vertically at 24 inches below the surface of the water were higher and ranged widely. For example, the reading of 13,083 i.p.m. in galvanized iron pipe was only 53 percent as large as the 24,652 i.p.m. reading in aluminum. Therefore, the slope of the calibration curve for aluminum tubing was much steeper than for galvanized iron pipe. The slopes of the curves for the other tubes fell between the two extremes of aluminum and iron.

Recommendations

1. Subsurface moisture nuclear probes should be calibrated in the same kind of tubing that is to be used in the field application.

2. Individual field conditions should dictate the tubing material used. All the tubes we tested were technically satisfactory for our purposes.

3. Use aluminum or plastic tubing to detect small changes in soil moisture.

CALIBRATE NUCLEAR EQUIPMENT WITH BUILT-IN ELECTRONIC TIMERS

In using these nuclear devices an impulse rate must be obtained and this necessitates the use of some sort of timer. We compared a known standard with results obtained using a stopwatch with a 60-second sweep, a stopwatch with a 10-second sweep, and an electronic timer sold as an accessory to the nuclear scaler.

The radioactive probe was not used. Instead, the scaler was connected to an ordinary 110-volt, alternating current and readings were made of the 60-cycle-per-second current alternations. A group of 28 one-minute readings was made for each timing device:

Timing method	Average reading (i.p.m.)	Difference from 3,600	Variance
Stopwatch, 10-second sweep	3,601	+ 1	12.5
Stopwatch, 60-second sweep	3,596	- 4	35.3
Electronic timer	3,589	- 11	.407

Differences between the average i.p.m. (impulse per minute) readings of the two stopwatch methods and the electronic timer method were all significant at a probability level lower than 1 percent. However, the difference between the average reading obtained with the stopwatch with a 10-second sweep and the expected 3,600 i.p.m. was not significant even at the 10 percent probability level.

The stopwatch with a 60-second sweep gave consistently low readings. The difference between the average of these readings and the expected value was statistically significant at the 1/2 of 1 percent level of probability.

The electronic timer gave the lowest readings, and the average for this method was furthest from the expected 3,600 i.p.m. Evidently this timer did not allow the scaler to run a full minute and the method contains a bias that is statistically significant at a probability level of less than 1/10 of 1 percent. The electronic timer did, however, give the most consistent readings.

Recommendations

Obtain scalers with built-in, electronic timers. They may not give exact 1-minute or 2-minute intervals of time but interval variation is very small and electronic timers are easier and faster to use in the field.

A correction in the calibration curve should be made to eliminate bias caused by the electronic timer. The independent variable of the corrected calibration curve should show "impulses per electronic timer interval" rather than "impulses per minute."

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